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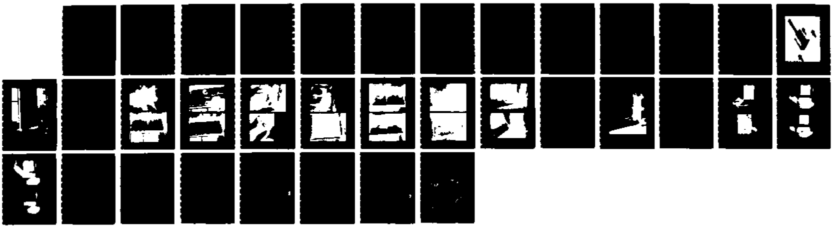

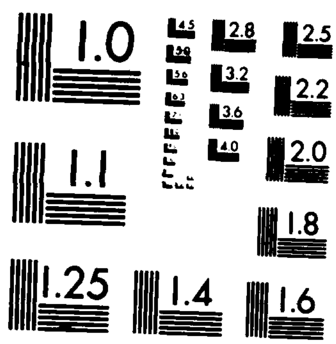

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Technical Note

September 1986

By J. F. Jenkins

Sponsored by Naval Facilities Engineering Command

Corrosion and Corrosion Control of Hush House Interiors

ABSTRACT **The interior of in-frame gas turbine test facilities, commonly referred to as hush houses, is constructed using galvanized steel box sections filled with fibrous acoustic material and covered with perforated galvanized steel plate. The exposed surfaces of the perforated plate have been found to be subject to corrosion at several hush houses. In this report the severity of the corrosion damage on both the perforated liner plate and the interior of the box sections was evaluated, and the corrosion was found to be not structurally serious at this time. Recommendations for removing trapped water from the interior sections, for preventing the ingress of additional water, and for cosmetically repairing existing corrosion damage were formulated and are presented.**

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METRIC CONVERSION FACTORS

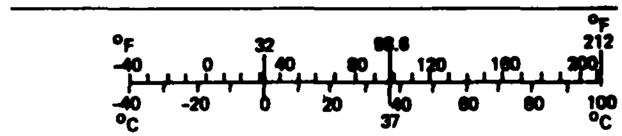
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The interior of in-frame gas turbine test facilities, commonly referred to as hush houses, is constructed using galvanized steel box sections filled with fibrous acoustic material and covered with perforated galvanized steel plate. The exposed surfaces of the perforated plate have been found to be subject to corrosion at several hush houses. In this report the severity of the corrosion damage on both the perforated liner plate and the interior of the box sections

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TN-1758 28 pp illus September 1986 Unclassified

1. Corrosion 2. Hush House I. YF61.544.091.01.031

The interior of in-frame gas turbine test facilities, commonly referred to as hush houses, is constructed using galvanized steel box sections filled with fibrous acoustic material and covered with perforated galvanized steel plate. The exposed surfaces of the perforated plate have been found to be subject to corrosion at several hush houses. In this report the severity of the corrosion damage on both the perforated liner plate and the interior of the box sections was evaluated and the corrosion was found to be not structurally serious at this time. Recommendations for removing trapped water from the interior sections, for preventing the ingress of additional water, and for cosmetically repairing existing corrosion damage were formulated and are presented.

CONTENTS

INTRODUCTION

Facilities for the in-frame testing of gas turbine engines, commonly referred to as hush houses (Figure 1), are a relatively new addition to the inventory of Naval shore facilities. Soon after these facilities were introduced to field use, corrosion of the interior perforated galvanized steel liner plates became evident as shown in Figure 2. Several concerns over the potential impact of this corrosion were expressed and can be summarized as follows:

- Is the damage structurally significant?
- Is the corrosion on the interior of the sections more serious than on the exterior?
- Is the corrosion damage a potential source of foreign object damage (FOD) (foreign objects that cause damage to gas turbine engines)?
- What is the cause of the damage?
- Can the damage be arrested?
- Can the appearance of the interior surfaces be restored?

This report is based on the inspection of a typical hush house at the Marine Corps Air Station (MCAS), El Toro and on laboratory investigations performed at the Naval Civil Engineering Laboratory (NCEL).

INITIAL INSPECTION OF HUSH HOUSE INTERIOR

In June 1983, the exterior of the perforated liner plate was inspected. The corrosion damage was widespread. As shown in Figure 2, it was generally concentrated at the lower portions of the sections and, to a lesser extent, at an area approximately 4 feet above the bottom of the sections. The corrosion damage, which ranged from a light covering of white corrosion products to red rust, was typical of galvanized steel exposed to a rural-type exterior atmosphere. The areas of most severe corrosion damage were adjacent to the firefighting hose and to the hose bibs on the two lateral walls. Above the 8-foot level there were scattered areas with a very thin layer of white corrosion products.

REMOVAL AND REPLACEMENT OF LINER SECTION

In July 1983, a section of perforated liner plate was removed from the interior of the hush house at MCAS El Toro to inspect the interior of the building section and to obtain a sample of deteriorated liner plate for laboratory analysis. Figure 2 shows the condition of the section prior to removal. Figure 3 shows the location of the section that was removed. The section was selected for two reasons. First, it was one of the most seriously deteriorated sections. Second, the liner sections on the lateral walls were very difficult to remove and replace due to their configuration. In the initial building construction, the wall sections were prefabricated and tilted into place. The restraining beams on the interior of the walls would have interfered with the removal and replacement of the section.

The first step in the removal of the test section was the removal of a vertical angle. The plug welds between the angle and the plate were removed using an air-arc torch, and the angle was cut just above the test section. The angle was then unbolted and removed. This exposed the entire periphery of the test section. The remaining plug and stitch welds attaching the test section were removed using an air-arc torch. Figure 4 shows the test section after all welds were removed.

During the removal of the stitch welds at the bottom of the test section, water leaked from a point where both the liner panel and support section had been cut through. This is shown in Figure 5. Water continued to run from the hole for about 10 minutes.

After all of the welds had been cut, the panel was removed and the acoustic material was exposed and inspected. As shown in Figure 6, the fiberglass material was stained. As shown in Figure 7, the material in the first layer of insulation was inspected for moisture before removal and was found to be dry to the touch. The fiberglass cloth covering the outer section of the acoustic material was, however, water stained. The outer section of the acoustic material was removed and unwrapped. The lower section of the material was significantly deteriorated, and it easily crumbled when handled as shown in Figure 8. The inner section of acoustic material was then removed. Portions of this material adhered to the interior plate of the section (see Figure 9) but were easily removed by light scraping. The acoustic material was retained for future evaluation in a separate work unit.

The panel used to replace the test panel was nearly identical to the test panel. The replacement panel was rectangular, whereas the test panel was trapezoidal. The perforated areas were equal within 1/2 inch. Both panels were hot dip galvanized after perforating. New acoustic material was cut to size and fitted into the test section in two layers. The outer layer was wrapped in new fiberglass cloth prior to installation.

After new acoustic material was installed, the replacement panel was cut to size and welded into place. Areas where the welding damaged the galvanized coating were coated once with TT-P-641 applied with a brush. After the corner angle was bolted into place, it was also coated with TT-P-641. After the panel replacement was completed, the area was cleaned and the hush house was returned to operational status. Figures 10 through 13 show the replacement sequence.

CONDITION OF TEST SECTION INTERIOR

Figures 14 through 16 show the condition of the interior of the test section. The corrosion damage on the interior of the test section was qualitatively equivalent to the corrosion damage on the exterior of the liner plate, and it was greatest on the lower portions of the section. Figure 17 shows the point of ingress of water that was trapped in the lower support channel of the section. Figure 18 is a sketch of the lower support channel showing where water was trapped. A 1- by 2-inch hole was cut in the top of the support channel to determine how full the section had been. The presence of wet rust on the upper surface of the section interior indicated that the section had been completely filled. However, the loss of material was not significant. The inspection hole was sealed prior to installation of the replacement acoustic material. A second area where water could be trapped and held was found at the midspan support as shown in Figures 19 and 20.

LABORATORY EVALUATION OF TEST LINER PANEL

The liner panel section that was removed was returned to the Naval Civil Engineering Laboratory for quantitative evaluation of the extent of corrosion damage to the panel and evaluation of cosmetic repair procedures. To quantitatively evaluate the extent of corrosion damage on the panel, the areas displaying various levels of corrosion damage were estimated on both the front (obverse) and back (reverse) of the panel using a transparent grid with 1-inch square sections. Four levels of deterioration were established: none, white corrosion products, tan corrosion products, and red rust. "None" indicated a lack of any evidence of corrosion damage. "White corrosion products" indicated that the outer layer of relatively pure zinc in the outer layers of the galvanized coating was damaged. "Tan corrosion products" indicated that the corrosion damage had extended through the relatively pure zinc outer layers and to the zinc-iron alloy layers adjacent to the original surface of the panel. "Red rust" indicated that the galvanized coating had been consumed and the steel panel had begun to corrode. The results of these measurements are given in Table 1.

To both measure the depth of corrosion damage and to validate the effectiveness of an ultrasonic thickness gage in the measurement of panel thickness from one side, a micrometer and an ultrasonic thickness gage were used to measure the panel thickness at 10 locations where each type of corrosion condition was observed on the front (obverse) side of the panel after the corrosion products were removed with a bristle brush. The results of these measurements are given in Table 2.

Cosmetic repair procedures were developed for removing corrosion products from corroded areas of the liner plate and for recoating the plate to give both corrosion protection and a uniform appearance similar to the original galvanized liner. The procedure and materials selected do not require special skills or equipment and are applicable to in-place perforated liner plates. The coating system selected for evaluation is a standard zinc/zinc oxide organic coating TT-P-641. Hand wire brushing was used to prepare the surface. Where red rust was present the hand wire brushing was augmented by limited hand sanding with 120-grit

silicon-carbide abrasive paper. To evaluate the ability of the coating procedure to coat the outer surface of the perforated panels without either filling the perforations or coating the underlying fiberglass cloth, a test setup (Figure 21) was devised to model the in-place arrangement of the liner plate. The selected coating, a two-component coating consisting of a liquid and a powder, was mixed in accordance with the instructions on the containers prior to application of the paint. The coating was applied using a 3/8-inch nap roller. The roller was loaded with paint, and then the excess paint was removed from the roller by rolling it out into the paint tray. The paint was applied in two thin coats, giving a total dry film thickness of 6 mils (0.006 inch). The coating procedure is illustrated in Figures 22 through 25. As shown in Figure 26, the backing material under the test panel was not contaminated during coating.

CONCLUSIONS

Based upon both the field and laboratory studies performed in this task, the following conclusions regarding the liner corrosion problem at MCAS El Toro are offered:

1. At the present time the corrosion of the liner plates and of the interior of the sections is not structurally significant. The thickness loss of the liner plate did not exceed 0.032 inch in the areas of greatest corrosion damage. However, since the thickness of the galvanizing was 0.004 inch on each side, the structural thickness loss did not exceed 0.024 inch or 5%.

2. The condition of the interior of the section was essentially the same as the exterior. With the exception of areas that trap and hold water, the extent of corrosion is effectively the same.

3. At the present time the potential for FOD resulting from the corrosion of the liner plates is very low. The corrosion damage has not proceeded to the point where loss of a section of liner plate or the separation of a complete plate from its supports is likely. The FOD potential from the amounts of corrosion products found on the exterior surfaces of the liner plates is also small.

4. The ultrasonic thickness gage is an effective and accurate tool for measuring perforated liner plates in hush houses.

5. The most likely cause of the corrosion damage observed is the wetting of the interior of the hush house during cleaning. The location of the most serious damage, the condition of the acoustic insulation material, the corrosion of the interior of the test section, and the presence of trapped water all confirm this hypothesis. The corrosion can be arrested by eliminating future wetting of the hush house interior and by draining the water trapped in interior sections.

6. The appearance of the interior surfaces of the hush house can be restored by the in-place coating of the liner panels and other corroded areas with TT-P-641.

RECOMMENDATIONS

1. Where corrosion is visible on the interior surfaces of the hush house, the extent of damage should be assessed by visual examination and ultrasonic thickness measurements.

2. The potential for wetting of the interior of the hush house during routine operation or cleaning should be eliminated by modifying either the facility or the procedures.

3. As shown in Figure 27, sections where water could be trapped should be drained by drilling drainage holes as noted.

4. The lower sections of the interior should be cleaned and coated as described previously to achieve a uniform finish.

ACKNOWLEDGMENTS

The author wishes to acknowledge Messrs. Aguilar and Roddenbeck, GySgt Williams of MCAS El Toro, and Mr. Stone of NCEL for their cooperation and assistance in the inspection of the hush house; and Messrs. Gaberson, Kling, Mitchell, and Osgood of NCEL for their efforts in the successful removal and replacement of the test panel.

Table 1. Measurement of Corroded Areas

Rating	Obverse Area		Reverse Area	
	in.^{2}	%	in.^{2}	%
None	2,338	59	2,445	62
White Corrosion Products	1,149	29	1,028	26
Tan Corrosion Products	356	9	376	9
Red Rust	119	3	113	3
Combined Areas of Tan Corrosion Products and Red Rust	475	12	489	12

Table 2. Thickness Measurements (in.)

Rating	Micrometer			Ultrasonic		
	Minimum	Average	Maximum	Minimum	Average	Maximum
None	0.479	0.481	0.483	0.476	0.477	0.479
White Corrosion Products	0.470	0.474	0.476	0.468	0.476	0.478
Tan Corrosion Products	0.459	0.463	0.469	0.460	0.465	0.469
Red Rust	0.451	0.464	0.473	0.449	0.464	0.474

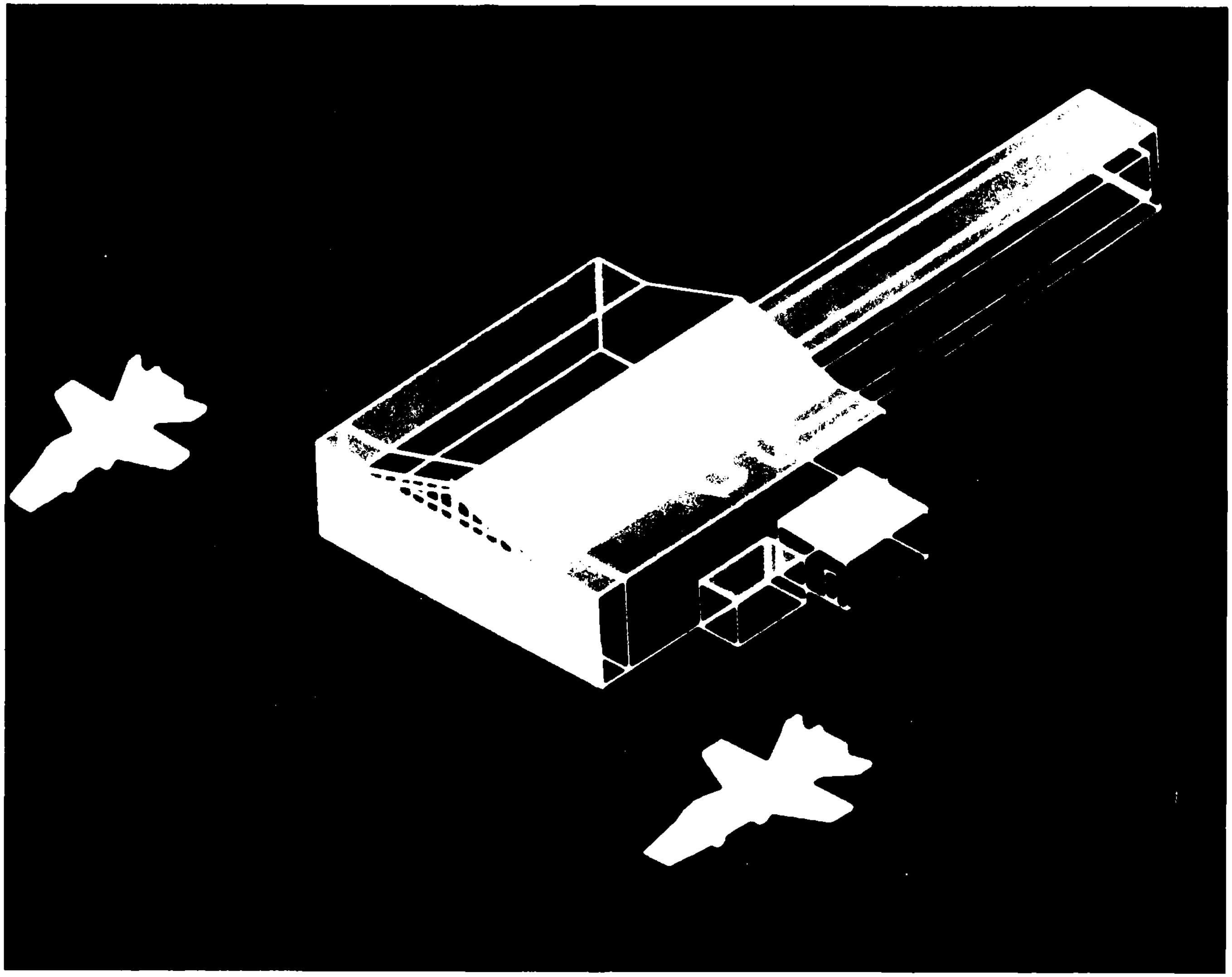

Figure 1. General view of hush house exterior.

Figure 2. Example of liner corrosion at lower section near fire hose.

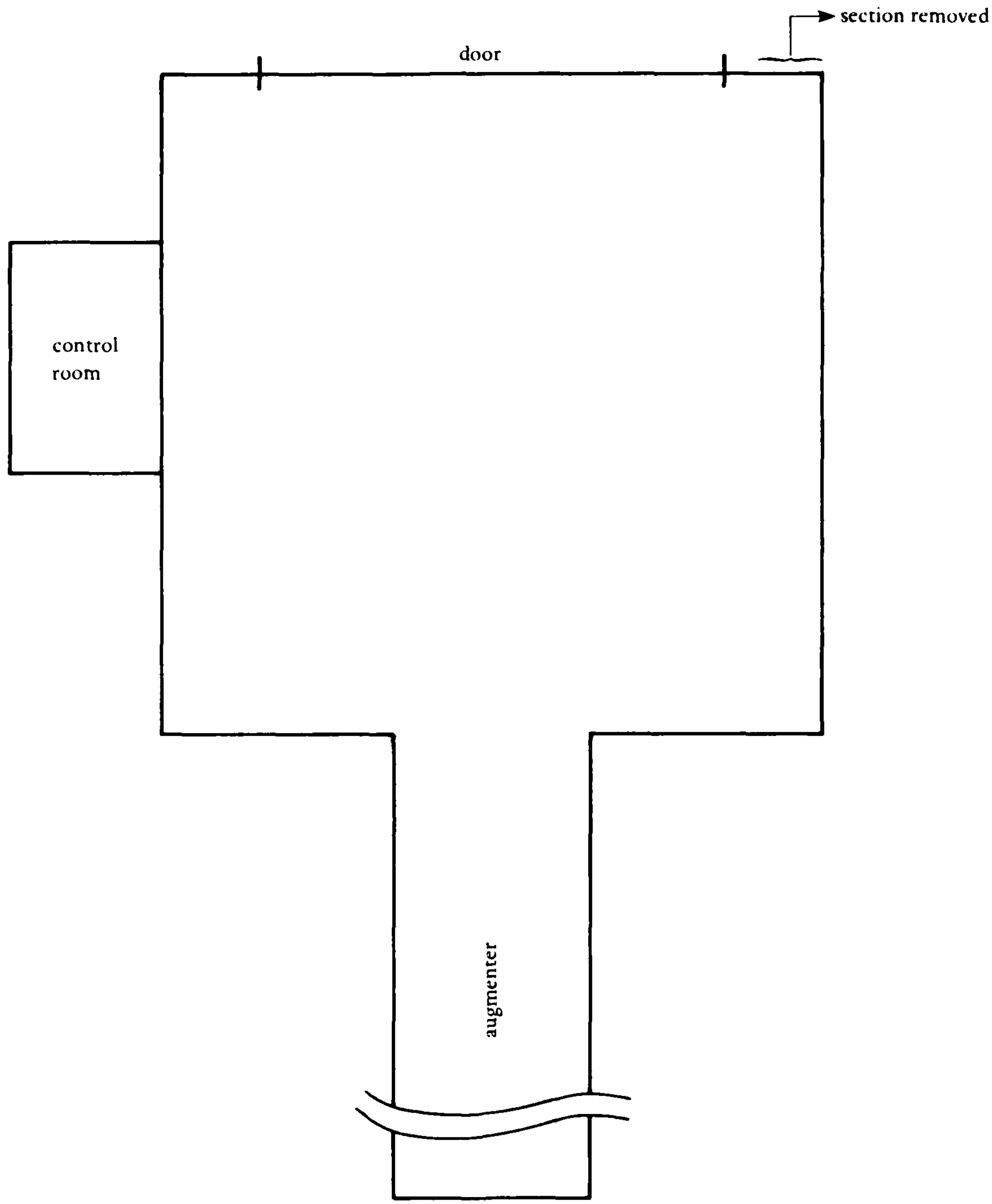

Figure 3. Sketch of the location of the liner plate section removed for analysis.

Figure 4. Test section with welds removed.

Figure 5. Water running from interior of section.

Figure 6. Water stains on fiberglass covering.

Figure 7. Inspection of acoustic material for moisture.

Figure 8. Acoustic material that crumbled during handling.

Figure 9. Inner layer of acoustic material on inner liner.

Figure 10. Inner layer of acoustic material in place.

Figure 11. Wrapping outer layer of acoustic insulation with fiberglass cloth.

Figure 12. Attaching replacement panel.

Figure 13. Completed installation.

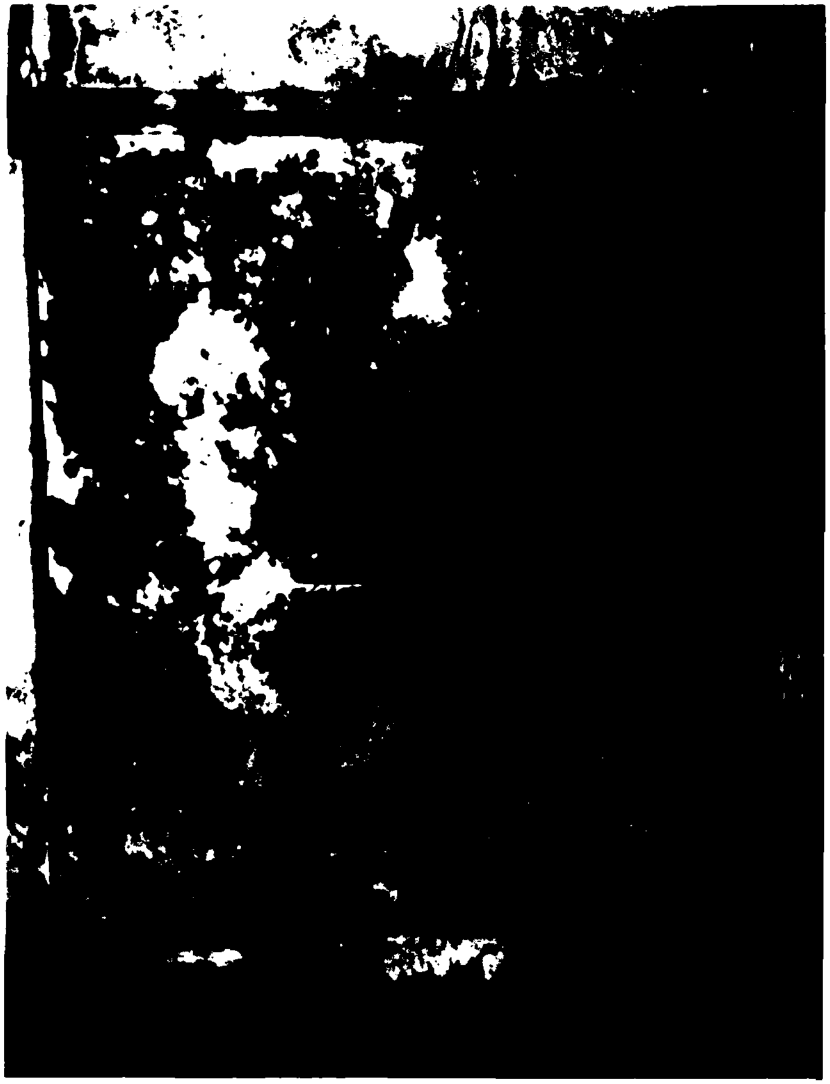

Figure 14. Condition of section interior.

Figure 15. Areas of red rust on interior plate.

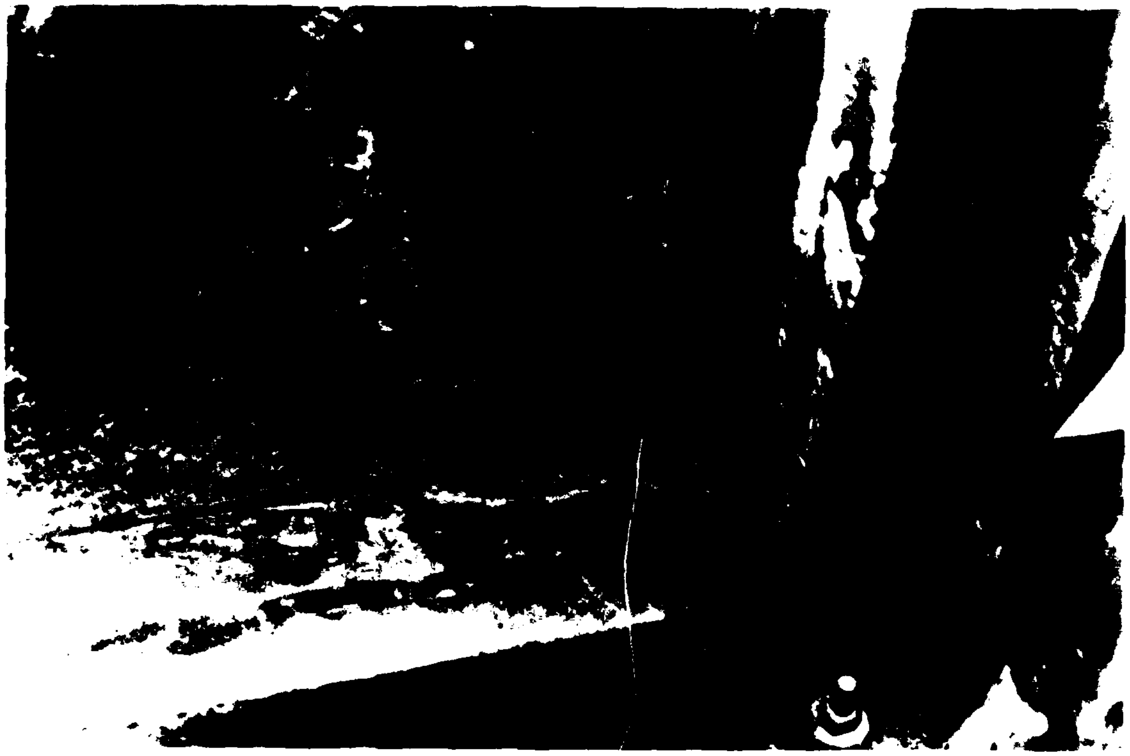

Figure 16. Upper surface of lower support channel showing accumulation of white corrosion products.

Figure 17. Point of water ingress on lower support channel.

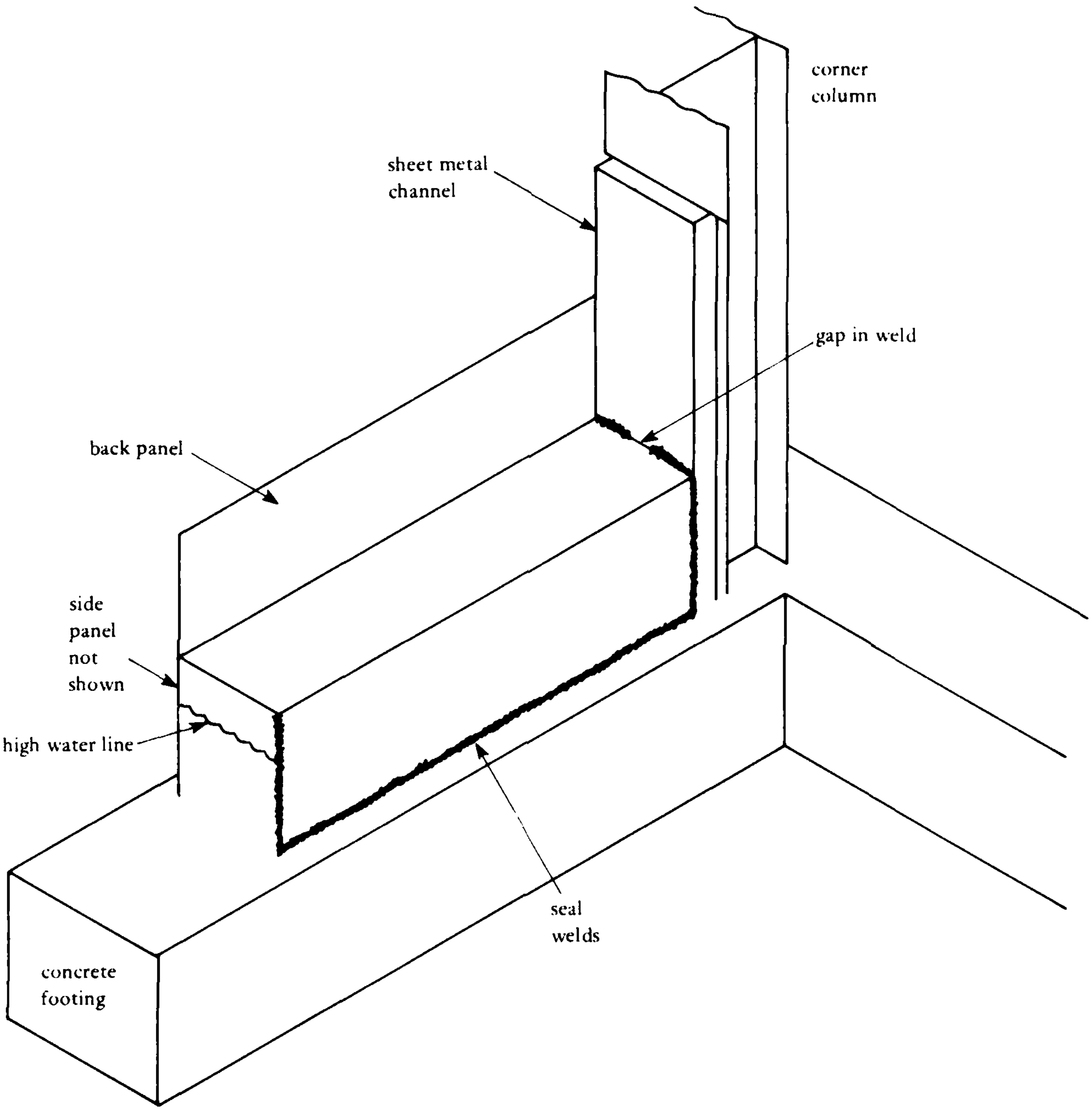

Figure 18. Sketch of lower support channel showing water entrapment mechanism.

Figure 19. Midspan support showing evidence of water entrapment.

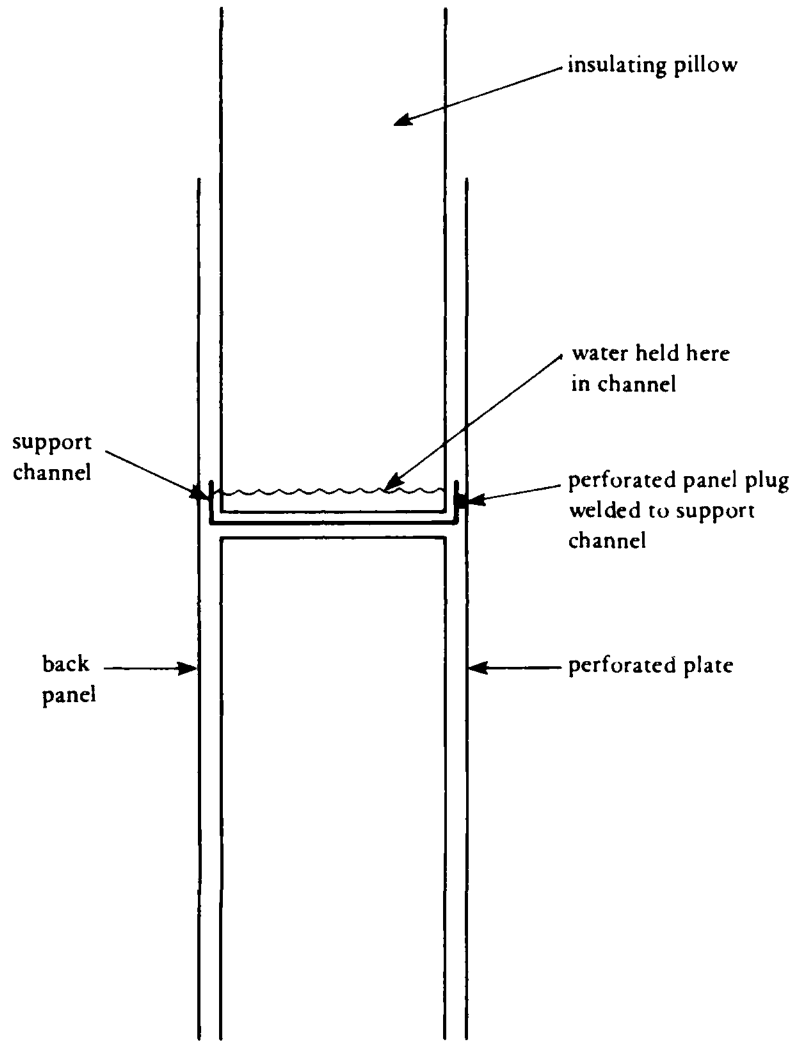

Figure 20. Sketch of midspan support showing water entrapment mechanism.

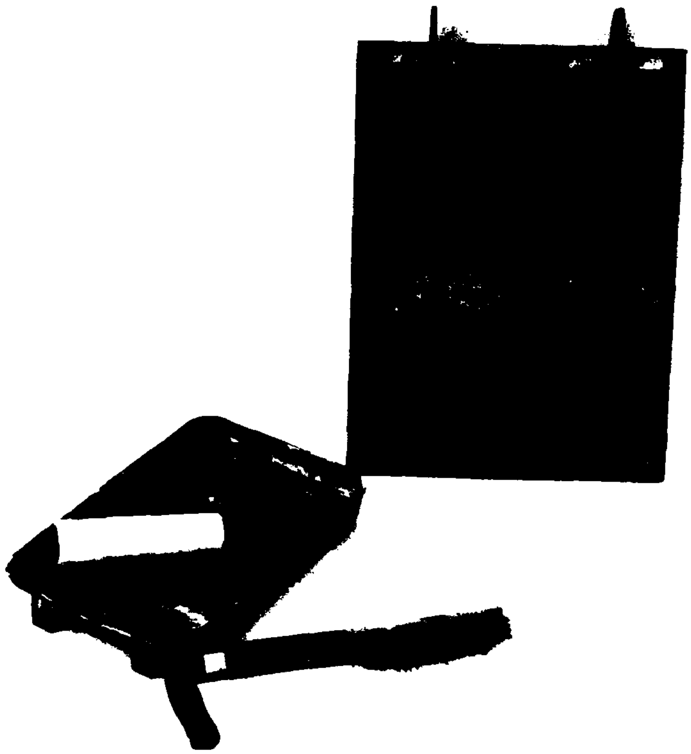

Figure 21. Setup for evaluation of coating procedure.

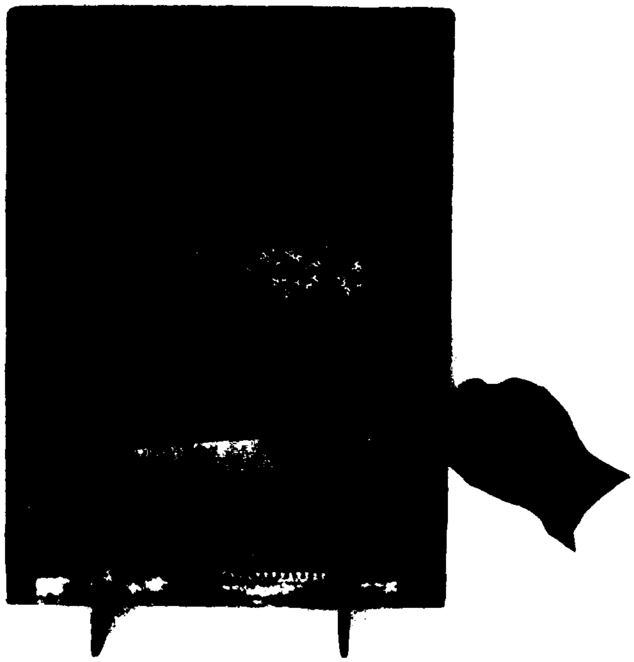

Figure 22. Wire brushing the panel.

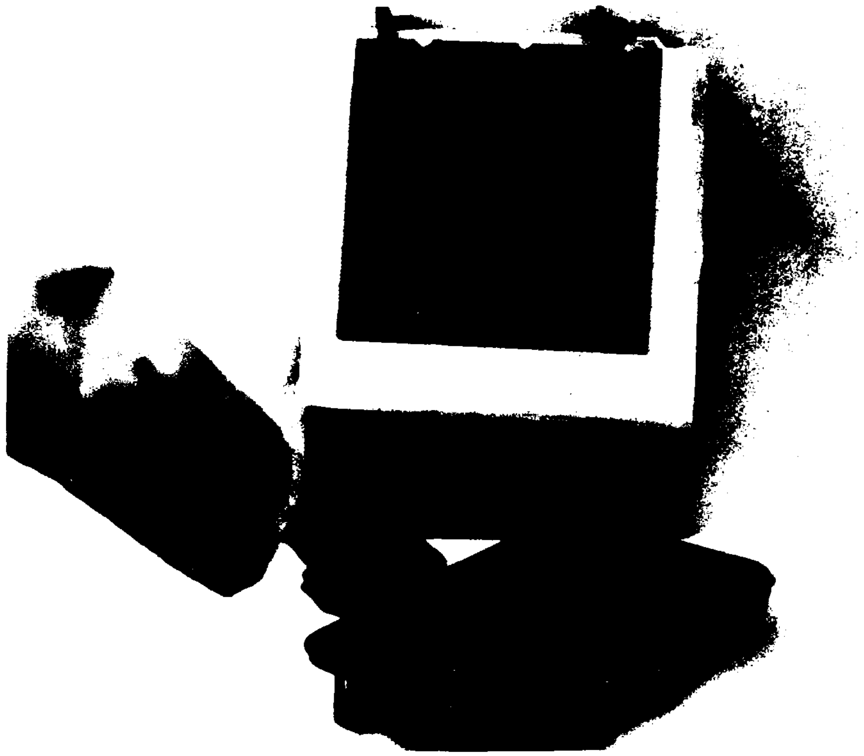

Figure 23. Filling the roller.

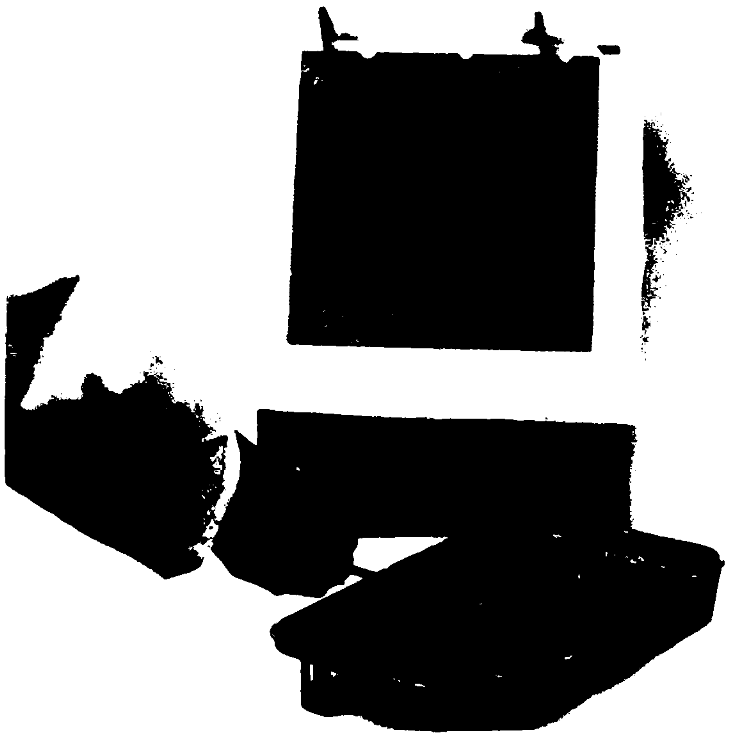

Figure 24. Rolling out the excess paint.

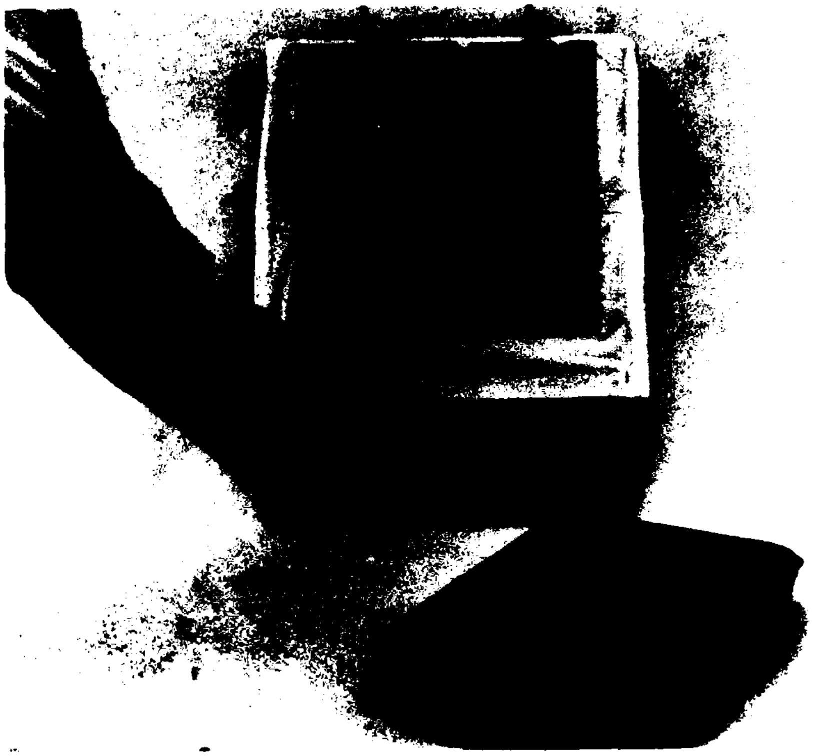

Figure 25. Applying the paint.

Figure 26. Backing material showing absence of paint.

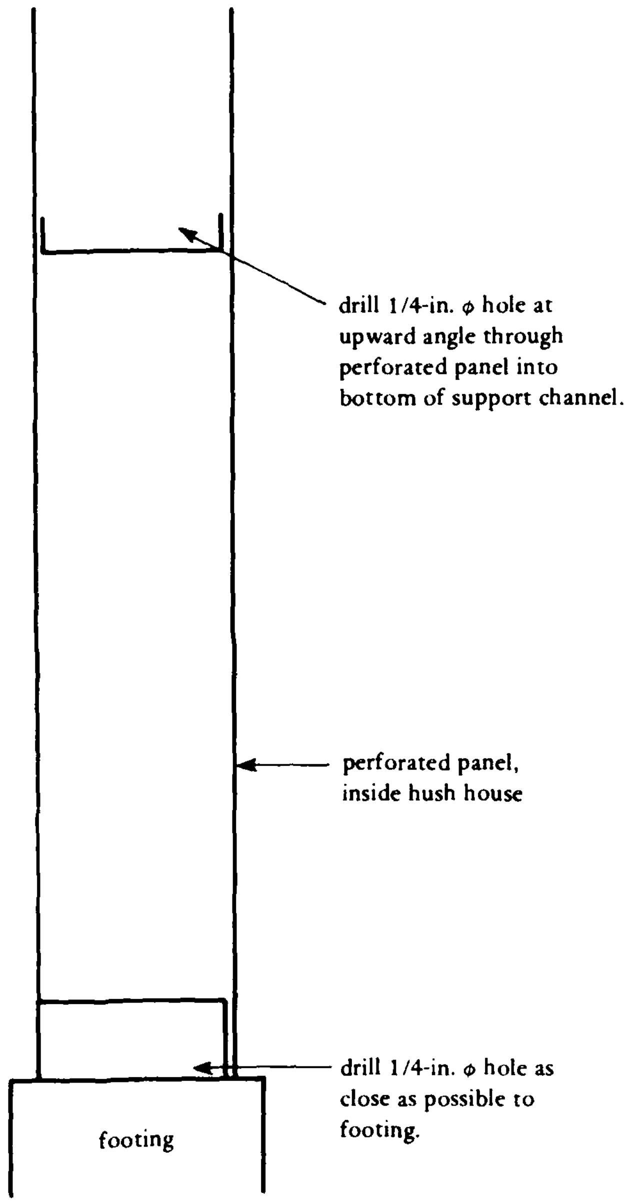

Figure 27. Recommended drainage points.

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